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Abstract

Potentialities of heavy-water moderated gas cooled pressure tube reactors

by

W. Keller

Siemens-Schuckertwerke AG

Big heavy-water moderated power reactors are, if properly designed, the best thermal converters on the uranium fuel-cycle, and potentially near breeders on the thorium fuel-cycle. Amongst several possible coolants for such a reactor, CO_2 shows various important advantages: First, it is the low neutron absorption of the coolant, which allows, in connection with a low absorbing fuel canning material, a fuel cycle with natural or slightly enriched uranium. With natural uranium in form of UO_2 fuel burn-ups of 8000 MWd/t should be achievable. Secondly, CO_2 is compatible with many structural materials at high temperatures. These make it possible to obtain steam conditions similar to those of modern conventional steam power stations. Thirdly, the D_2O-CO_2 pressure tube reactor has the advantage that the heavy-water is kept at a low temperature and nearly at atmospheric pressure. The risk of heavy water losses is therefore kept very low, especially because loading and shuffling of fuel under power can be accomplished without disturbing the integrity of the heavy-water circuit. Fourthly, as the UO_2 is compatible with CO_2, small canning failures will not lead to serious consequences. With UO_2 and very low enrichment there is every hope for reaching high burn-ups in the range

of 20 000 MWd/t, and low fuel cycle costs. In addition to these advantages CO_2 at high pressure (80 - 120 ata) permits power densities comparable to those in water cooled D_2O-cores.

Four years of development at Siemens-Schuckertwerke AG in connection with a design contract by Atomkraft Bayern for a CO_2-D_2O prototype plant of 100 MW_e, lead us to the conviction that the potentialities of this reactor-type can be realized in the near future. At 550°C reactor outlet temperature the use of low alloyed steel for the primary circuit seems feasible; while as canning material of the fuel rods very thin stainless steel may be used, special zirconium alloys show even more favourable prospects, beryllium, besides this, not being out of the picture.

Extrapolations to larger plants (> 300 MW_{el}) are leading to construction costs, which are as low as in any other heavy-water reactor concept as yet proposed. The familiarity of CO_2-technology should permit scaling up to plants of larger size at an early date.